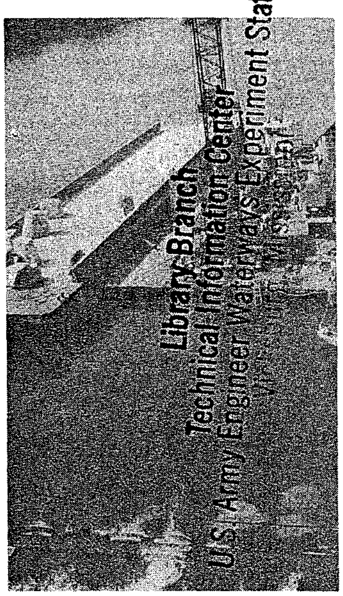
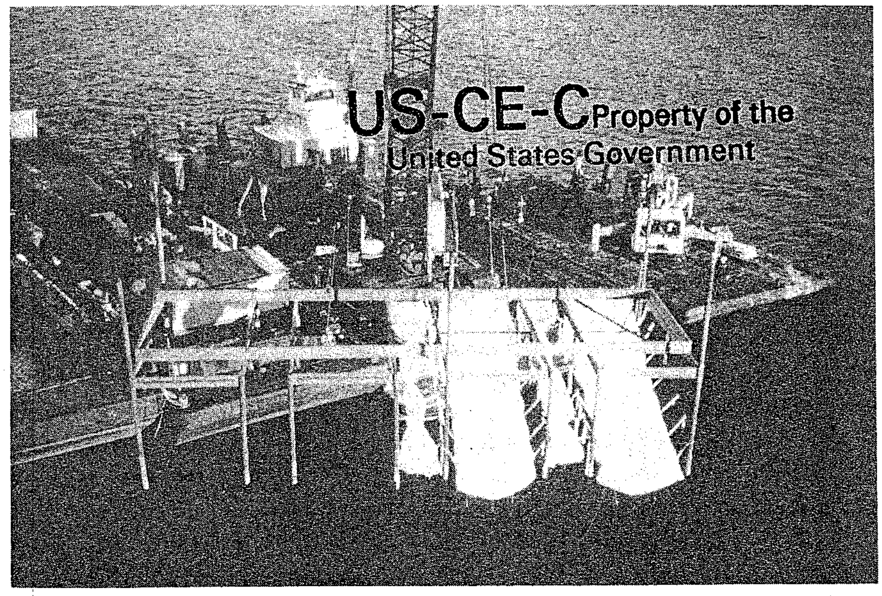


The REMR *Bulletin*

News from the Repair, Evaluation, Maintenance, and Rehabilitation Research Program

VOL 3, NO. 1 **INFORMATION EXCHANGE BULLETIN** **APR 1986**



Lowering large fabric bags into place prior to filling them with grout as a substitute for large riprap, Emsworth Dam, Ohio River

Current Methods for Repairing Scoured Areas Downstream from Stilling Basins

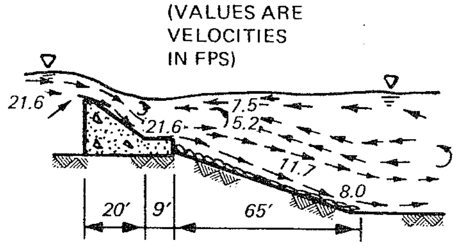
by John E. Hite, Jr.
US Army Engineer Waterways Experiment Station

Scour downstream from existing Corps of Engineers hydraulic structures is a problem faced by many Districts. In most cases, the scouring is caused by operating a structure beyond the range of conditions for which it was designed, especially when the original riprap protection placed downstream of the stilling basin is inadequate for this type of operation. There is much concern that if precautions are not taken to prevent additional scouring below many Corps structures, some of our stilling basins may be undermined and eventually fail.

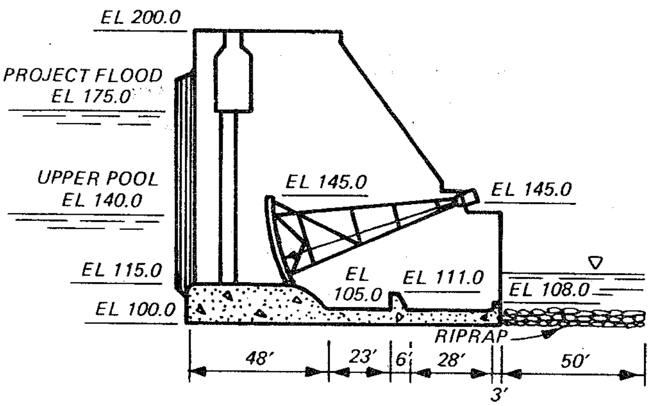
A four-year REMR work unit entitled "Scour Downstream from Stilling Basins" is currently under way to develop guidance for repairing damaged areas below these structures. The initial portion of this research effort has involved reviewing literature on the subject of scour protection and contacting Corps Districts to identify current methods being used by field offices to repair damaged areas.

PREVIOUS HYDRAULIC MODEL STUDIES

Physical model studies conducted in years past to develop scour protection for existing low-head navigation structures have found similarities in the causes of scour for given structure types. These studies were of both gated structures and uncontrolled fixed-crest



a. UNCONTROLLED FIXED-CREST DAM WITH PLUNGING JET FLOW



b. GATED STRUCTURE

Figure 1. Cross sections of typical structures showing downstream protection

dams (Figure 1), many of which do not have a true stilling basin but rather a short spillway apron for energy dissipation. Most of the projects with stilling basins are gated structures.

Scour Protection Below Uncontrolled Fixed-Crest Dams

From the model studies, it is apparent that scour below uncontrolled fixed-crest dams is caused by jet flow that plunges down the face of the spillway and exits the spillway apron with velocities often greater than 20 fps. This plunging jet flow (Figure 1a) probably causes piping of the material beneath the original rock protection permitting the rock to sink. Under certain conditions, this type of flow is strong enough to actually displace the rock protection.

Typically, scour protection plans developed from model studies of uncontrolled fixed-crest dams have included structural modification to the existing stilling basin or spillway apron and/or the use of large rock below the structure. (Large rock is considered to be that weighing more than 5500 pounds per stone.)

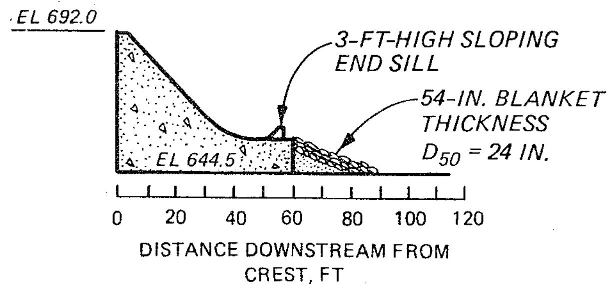


Figure 2. Scour protection plan for Dashields Dam, Ohio River

A scour protection plan developed from a model study of Dashields Dam, Ohio River (Figure 2), called for installing a 3-foot-high sloping end sill as close to the end of the apron as possible, but no farther than 3 feet upstream from the end of the apron. A 54-inch blanket of graded riprap with a D_{50} size of 24 inches (i.e., 50 percent of the stone having at least a 24-inch diameter) was placed on a 1V-on-3H downward slope beginning at the apron elevation and terminating on firm rock approximately 35 feet downstream.

Another example of a structural modification to an existing spillway apron was developed in a model study of scour protection for Dam No. 7, Allegheny River. A 28-foot extension to the spillway apron employing sunken barges filled with grouted riprap and 3- to 4-foot-diameter stone offset below the extension and sloped downward 1V on 3H were required to provide adequate protection (Figure 3).

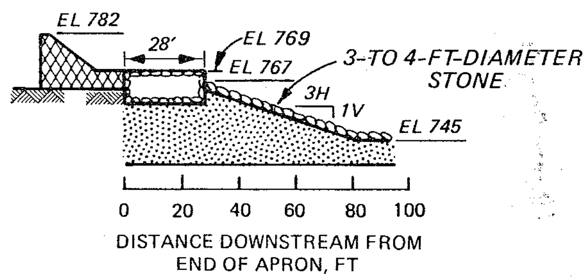


Figure 3. Apron extension for Dam No. 7, Allegheny River

Scour Protection Below Stilling Basins of Gated Structures

Model studies of gated navigation structures have shown that scour below their stilling basins is generally caused by improper gate operation and/or inadequate energy dissipation. Improper gate operation can be due to any one or more of the following: operator error, equipment malfunction, vandalism, or operating the structure beyond its normal operating range to pass ice or debris. Inadequate energy dissipation in the stilling basin can be attributed to improper basin design or to project conditions differing from those anticipated when the basin was designed. An example would be tailwater elevations lower than expected due to a scoured streambed below the structure.

A protection plan developed from a model study of Pike Island Dam, Ohio River (Figure 4), was designed to withstand operations with a normal upper pool, one gate half open, and minimum project tailwater. These conditions exist when ice and debris are passed through the structure.

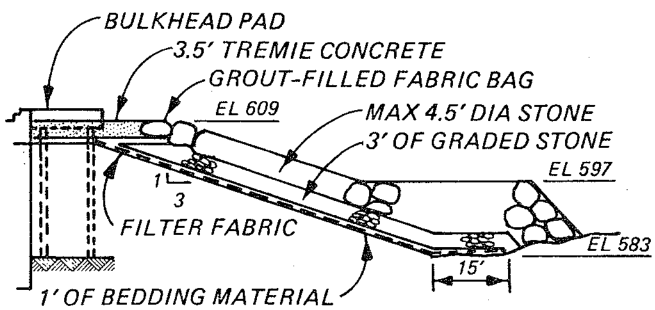


Figure 4. Scour protection plan for Pike Island Dam, Ohio River

Model studies of gated structures on the upper Mississippi River have shown that a graded riprap with a D_{50} size of 24 inches is adequate to protect the area downstream from the stilling basin when subjected to single-gate criteria. For these studies, single-gate criteria consisted of:

1. No permissible damage for extended operations with a single gate half open, normal pool, and minimum tailwater.
2. Only minor damage permitted with a single gate fully open, normal pool, and minimum tailwater.

ALTERNATIVES TO RIPRAP

Guidance for design of new stilling basins suggests that riprap protection downstream from the stilling basin be model tested with one gate fully open, minimum tailwater, and normal and above-normal pool elevations. Existing projects that are required to meet these criteria often need protection more substantial than riprap. Large grout-filled fabric bags, up to 20 feet long by 7 feet wide by 3 feet high, have shown promise as an alternative to riprap in these cases.

Model studies of scour protection for Emsworth Dam, Ohio River, revealed that the bags would be more stable than stone 4 to 5 feet in diameter. Subsequently, grout-filled bags were placed behind one of the gate bays at Emsworth after large riprap failed to remain in place. A frame with empty bags attached was lowered into place behind the gate bay (see cover photo), and the bags were then filled with grout pumped through a hose. This repair has been successful and offers encouragement for those instances in which large enough stone either is not available or is uneconomical.

A study of scour protection for Dam No. 2, Arkansas River, currently in progress at the Waterways Experiment Station (WES), has shown that barges filled with grouted riprap and sunk below the existing stilling basin (Figure 5) could serve as a secondary stilling basin to dissipate energy from flow conditions with one gate fully open and minimum tailwater.

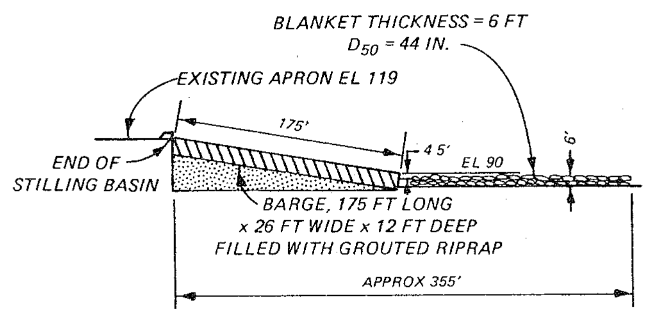


Figure 5. Scour protection plan for Dam No. 2, Arkansas River

PLANNING REPAIRS OF SCOUR PROTECTION

Successful repair of a scoured area below a stilling basin requires careful planning. Initially, the cause of the scouring should be determined. A close inspection of the project operation schedule and discussions with the operators may reveal that adverse flow conditions have occurred and may still be occurring, and these adverse conditions may be the cause of the scour.

An accurate hydrographic survey of the damaged area is essential in formulating the repair plan. Discussions among responsible officials from the affected District and Division and from Corps Headquarters should be used to establish the flow

(Continued on page 6)

Research Under Way on Problems with Estuarine and Deep-Draft Navigation Channel Training Structures

by Robert F. Athow, Jr., and Michael J. Trawle
US Army Engineer Waterways Experiment Station

In many cases deep-draft channels owe their continued existence to both the dredger and channel training structures. Much has been written about dredgers, their equipment, their working environment, and their problems; but very little about the maintenance problems associated with channel training structures.

Deep-draft channel training structures appear in a variety of forms, but their primary function is usually the same—constriction of a channel to increase the velocity of the water column and thereby (a) decrease the amount of sediment which might deposit in the channel and (b) even encourage erosion of the channel bottom. Structural forms range from simply connected piles to vertical walls and interconnected islands. Sizes also vary from piling structures as small as 40 feet in length to massive structures a mile or more in length. Timber pile (both treated and untreated) is one of the most common components of training structures; however, concrete piling, sheet piling, and rock-rubble combinations are also plentiful.

Navigation training structures are important in altering the hydraulic and sediment transport regime; therefore, Corps Divisions with coastal environments employ navigation training structures in a variety of locations and under a range of conditions within estuaries. The following list illustrates some of the many navigation training structure locations and types within tidal waterways:

Corps Division	*Structure Type*	*Location*
Lower Mississippi Valley	Headland and spur dikes	Southwest Pass, Mississippi River, LA
New England	Longitudinal dikes	Thames River, CT
North Atlantic	Spur dikes	James River, VA
North Pacific	Training wall and spur dikes	Everett Harbor, WA
South Atlantic	Spur dikes	Cooper River, SC
South Pacific	Training wall	Richmond Harbor, CA
Southwestern	Longitudinal dikes	Sabine-Neches Waterway, TX

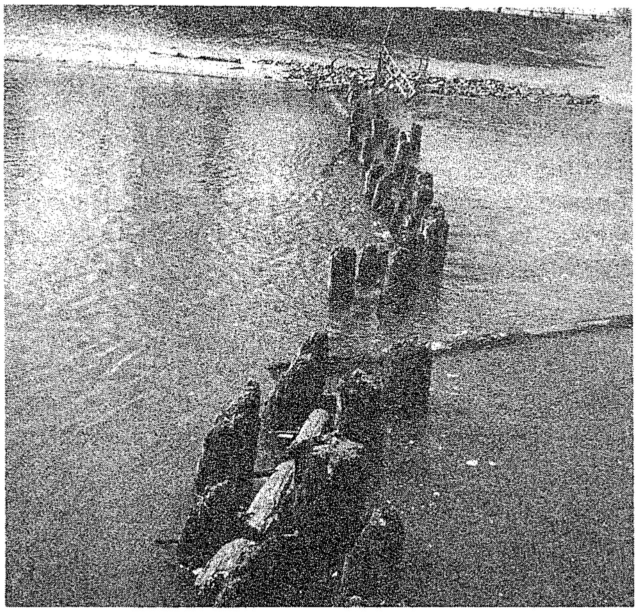
Many structures constructed based on physical model studies, like the Pea-Patch Island Dike in the Delaware River south of Wilmington, Delaware, function effectively even after they become severely deteriorated or partially destroyed. Other training structures do not function as designed after being damaged. For example, the Chinook Dike in the Lower Columbia River requires annual rehabilitation to function as designed.

A continuing drain on O&M funds in Portland District is the recurring repair of training structures damaged by ships, log rafts, etc., striking the structures. Although shipping firms are liable for damages they cause to training structures, catching them in the process of damaging a structure is not easy.

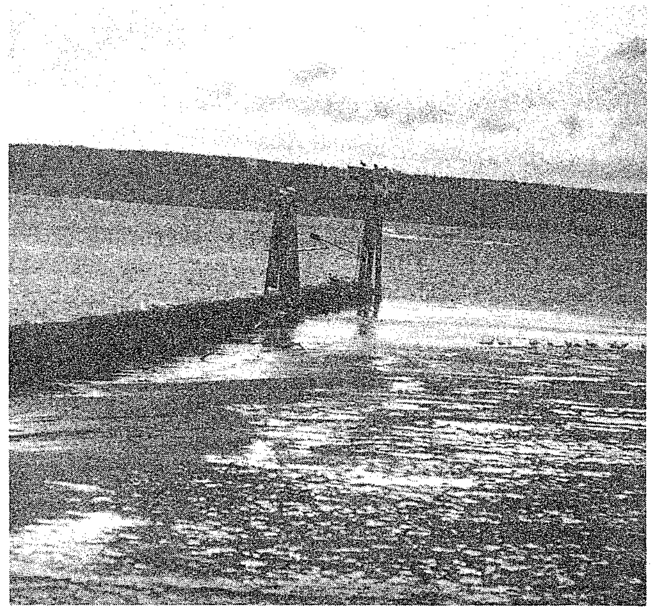
Other sources of recurring damage to training structures include deterioration due to age and decay, excessive scour at the mudline due to high current velocities, and towboat tie-offs. In New Orleans District, workboats and towboats frequently tie off to training structures while waiting for moorage, as well as for other reasons, because the structures are convenient locations on which the boatlines can be made fast. When the boats depart, the lines often are not untied; rather, they are simply pulled off over the top of the piling as the boat gets under way. Whole groups of piling are thereby subjected to severe lateral strains which they are not designed to withstand. Some piles are actually jerked free of the riverbed and remain attached to the structure only by the top spreaders.

Mudline scour at the channel end of training structures creates another dilemma. Training structures are designed to provide a cross-sectional restriction in order to increase flow velocities and thereby lessen the channel shoaling. However, if the flow velocities are of sufficient magnitude, they can also attack and move the structure toe protection material. Portland District has reported that in some cases the rock armor protection blanket around some structures disappears annually and must be replaced during the subsequent repair season.

Scour detection at the training structure mudline is also a problem. Estuarine and riverine channel areas rarely have clear, nonturbulent water in which visual and photographic inspections of the training structure foundation can be made. Acoustic methods show some promise in this area; however, water which has entrained air causes less than satisfactory results with these methods. Sounding lines or leadlines are the most used bottom detection



Spur dike constructed from untreated Douglas fir and suffering from age deterioration. At the landward end of the structure, a landowner has placed stone in an effort to control sloughing of the riverbank.



Training structure constructed to control shoaling near a river mouth. Slope failure of the outer end several years ago resulted in the loss of several hundred feet of the structure.

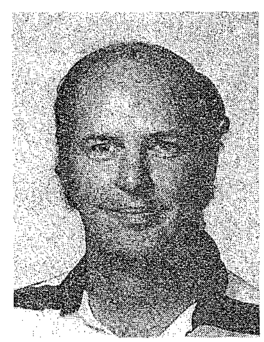
method but have the severe drawbacks of limited means of accurately positioning the sounding lead and of detecting small areas of incipient scour.

A related scour problem occurring at some training structures is flanking. Flanking occurs when streamflow erodes and breaches the bank-structure junction. The flanking problem is twofold: (a) at higher river or estuarine stages, flow passes around the training structure at the bank, reducing the constriction efficiency of the structure; (b) with currents flanking the structure, further bank erosion will occur.

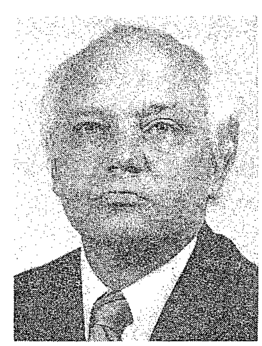
Research in FY 86 is focusing on:

- Development of methods for detecting scour damage at navigation training structures.
- Surveying scour detection equipment manufacturers, vendors, and contractors.
- Beginning the identification and evaluation of equipment and techniques for repair of scour damage.
- Selecting deep-draft field monitoring sites and beginning a monitoring program.
- Complete evaluation of current practices in deep-draft training structure repair and rehabilitation.
- Establishing guidelines for future deep-draft training structure repair practices.

Readers who have training structure repair and rehabilitation experience, whether in the form of observing problems or in developing solutions, are requested to contact the author, Bob Athow, at FTS 542-2135 or 601-634-2135. Also, if you have any deep-draft training structure repairs planned for the near future and desire to have them included in the on-going REMR evaluation, please contact him.



Bob Athow is a Research Hydraulic Engineer in the Estuarine Engineering Branch, Estuaries Division, Hydraulics Laboratory, WES. He received his B.C.E. from the University of Delaware and has done graduate work at Mississippi State and Texas A&M Universities. He is principal investigator for REMR Work Units 32323, "Scour Detection and Repair Around Navigation Training Structures," and 32324, "Repair Techniques at Navigation Training Structures."



Mike Trawle is a Research Hydraulic Engineer in the Estuaries Division, Hydraulics Laboratory, WES. He received his B.S. in civil engineering from the University of Texas at El Paso and his M.S. in civil engineering from Colorado State University and has done advanced graduate work at Texas A&M University. He is principal investigator for the Improvement of Operations and Maintenance Techniques (IOMT) Work Unit 32350, "Estuarine Channel Maintenance by Training Structures."

News In Brief

John Mikel, Chairman of the REMR Overview Committee, has been selected permanent civilian Assistant Chief, Operations and Readiness Division, Directorate of Civil Works, at Corps Headquarters, effective March 1, 1986.

Congratulations to **Tony Liu**, member of the REMR Overview Committee, on being appointed chairman of American Concrete Institute Committee 364, Rehabilitation, for a two-year term beginning in October 1985.

CPT Wylie K. Bearup has been reassigned from his duties as Deputy REMR Program Manager to the Military Programs section of the WES Office of Technical Programs and Plans. His contributions will be sorely missed, and we wish him well as he completes his tour in Vicksburg.

Dave Parsons and **Howard Kobayashi**, REMR Field Review Group members for Ohio River and Pacific Ocean Divisions, respectively, have both retired from federal service. Our best wishes to both for long and rewarding retirements. **Karl Keller**, Technical Engineering Branch, POD, will replace Kobayashi. No replacement has been named for Parsons; however, ORD is ably represented on the Field Review Group by **Jack Sirak**, who will continue to coordinate the REMR program there.

Gene Brickman, Engineering Division, North Atlantic Division, has been reassigned from the Foundation and Materials Section to the General Engineering Section. However, Gene will continue to serve as Field Review Group member for NAD.

Tony Kao has been named Problem Area Leader for the Operations Management problem area of the REMR Resarch Program. Tony replaces **Paul Howdyshell** who will continue as Problem Area Leader for the Electrical and Mechanical problem area.

A revised list of key personnel for the REMR Research Program is included as an insert to this copy of ***The REMR Bulletin***. Save it for a handy reference.

The American Concrete Institute has announced a 1986 continuing-education seminar called "Back-to-the Basics Repair of Concrete." ACI experts will lecture on and demonstrate basic, how-to fundamentals related to concrete deterioration as well as current repair methods and materials with proven performance. The seminar will be offered at: Cincinnati (April 16) and San Francisco (April 29). More information is available from the Education Department, American Concrete Institute, PO Box 19150, Detroit, MI 48219 or by calling 313-532-2600.

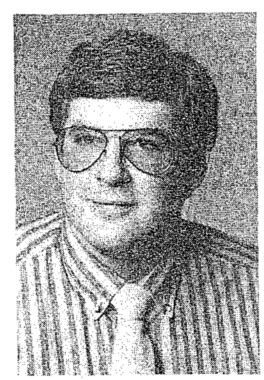
Current Methods for Repairing Scoured Areas Downstream from Stilling Basins (Continued)

conditions for which the scour protection must be designed.

Finally, close coordination between the hydraulic and geotechnical personnel involved in planning and overseeing the repair should be maintained to develop a functional scour protection system with proper underlying filters.

For additional information on current methods of repairing scour damage downstream from stilling basins, contact the author, John Hite, at FTS 542-2402 or 601-634-2402 or Glenn Pickering at FTS 542-3344 or 601-634-3344.

John Hite, a Research Hydraulic Engineer in the Hydraulic Structures Division, Hydraulics Laboratory, WES, is principal investigator for REMR Work Unit 32318, "Scour Downstream from Stilling Basins." In recent years, he has performed several site-specific studies of scour below navigation structures for Little Rock and Pittsburgh Districts. He received his B.S. in civil engineering from Mississippi State University and has been with the Corps since 1977.



LTG Heiberg Presented First Copy of *The REMR Notebook*

LTG E. R. Heiberg III, Chief of Engineers, receives the first copy of *The REMR Notebook* from COL Raymond Beurket, Deputy Director of R&D; Cecil Goad (left), Chief, Operations and Readiness Division, Directorate of Civil Works; and Bill McCormick, Chief, Engineering Division, Directorate of Engineering and Construction.

The first copy of *The REMR Notebook* was officially presented to LTG E. R. Heiberg III, Chief of Engineers, in ceremonies on February 14th at Corps Headquarters in Washington. Making the presentation were COL Raymond Beurket, Deputy Director, Directorate of R&D; Cecil Goad, Chief, Operations and Readiness Division, Directorate of Civil Works; and Bill McCormick, Chief, Engineering Division, Directorate of Engineering and Construction.

The REMR Notebook is an important new technology transfer product of the REMR Research Program. It contains information grouped in sections according to the seven REMR problem areas: Concrete and Steel Structures, Geotechnical, Hydraulics, Coastal, Electrical and Mechanical, Environmental Impacts, and Operations Management.

The information is presented in the form of one- to six-page REMR Technical Notes, each of which includes a statement of purpose, a point of contact for additional information or clarification, and other appropriate information such as when and where to apply the technology described, advantages and limitations of its use, costs and availability, and personnel requirements. Plans call for updating the notebook by issuing supplements containing new Technical Notes as well as any corrections or revisions that may be required to previously issued Technical Notes.

A special section of the notebook contains "Field Evaluation Cards" designed to collect information on:

- Suggested revisions, corrections, and additions to the notebook, and
- Concrete repair material experience.

Additional cards for collecting other information from the field will be issued in the future.

Six hundred copies of *The REMR Notebook* have been distributed to the Corps and to other government agencies. Copies will also be made available to non-government groups and individuals on a cost-reimbursable basis. For information on how to obtain a copy of the notebook, write: Director, US Army Engineer Waterways Experiment Station, ATTN: WESSC-A, PO Box 631, Vicksburg, MS 39180-0631, or call Tim Ables at 601-634-2587 or FTS 542-2587.

7th Field Review Group Meeting

The 7th Field Review Group meeting for the REMR Research Program will be held April 23 and 24, 1986, in the Clock Tower Building, Rock Island, Illinois, hosted by North Central Division. Registration will begin at 7:30 a.m. CST on April 23rd, and sessions that day and on the morning of April 24th will be open to the general public. Presentations will be made during the open sessions by REMR researchers on progress to date in the program and plans for future studies.

Reduced room rates are available at the Clayton House Motel in Davenport, Iowa (319-324-1921), for those attending the meeting. For more information on the meeting, contact Bill McCleese at FTS 542-2512 or 601-634-2512.

COVER PHOTOS:

LTG E. R. Heiberg III, Chief of Engineers, receives the first copy of *The REMR Notebook* from COL Raymond Beurket, Deputy Director, Directorate of R&D, in ceremonies on February 14th at Corps Headquarters in Washington, DC.

Placement of large-diameter derrick stone in scoured areas below Emsworth Dam, Pittsburgh District. The large stone subsequently washed out and had to be replaced with large grout-filled fabric bags.

The* REMR *Bulletin

The REMR Bulletin is published in accordance with AR 310-2 as one of the information exchange functions of the Corps of Engineers. It is primarily intended to be a forum whereby information on repair, evaluation, maintenance, and rehabilitation work done or managed by Corps field offices can be rapidly and widely disseminated to other Corps offices, other US Government agencies, and the engineering community in general. Contributions of articles, news, reviews, notices, and other pertinent types of information are solicited from all sources and will be considered for publication so long as they are relevant to REMR activities. Special consideration will be given to reports of Corps field experience in repair and maintenance of civil works projects. In considering the application of technology described herein, the reader should note that the purpose of *The REMR Bulletin* is information exchange and not the promulgation of Corps policy; thus, guidance on recommended practice in any given area should be sought through appropriate channels or in other documents. The contents of this bulletin are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. *The REMR Bulletin* will be issued on an irregular basis as dictated by the quantity and importance of information available for dissemination. Communications are welcomed and should be made by writing the Director, US Army Engineer Waterways Experiment Station, ATTN: T. D. Ables (WESSC-A), PO Box 631, Vicksburg, MS 39180-0631, or calling 601-634-2587 (FTS 542-2587).

Allen F. Grum

ALLEN F. GRUM
Colonel, USA
Director

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
PO BOX 631
VICKSBURG, MISSISSIPPI 39180-0631

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